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Discussion of
"STABILIZATION OF MUNICIPAL REFUSE BY COMPOSTING"

by P.H. McGauhey and Harold B. Gotaas
(Proc. Sep. 302)

P.H. McGAUHEY,[1] M. ASCE and HAROLD B. GOTAAS,[2] M. ASCE—Interest in composting as a method of solving municipal waste disposal problems has developed rapidly in the United States, and several composting plants have been built in other countries in the period since the authors originally presented their paper on "Stabilization of Municipal Refuse by Composting" in 1953. A healthy emphasis on producing compost on a commercial scale and deriving a profit from its sale in a competitive market is beginning to replace earlier attempts to profit by selling untried processes and secret inoculums.

There seems to be a general desire for a composting machine which can be sold or purchased as a package and which would free the user of concern with the unit operations of composting by enabling him to dump mixed refuse into one end and collect finished compost at the other. A number of such devices have been suggested, probably because of the obvious commercial possibilities of a one unit plant. Composting of municipal refuse, however, requires a series of operations which should be designed and engineered for the particular conditions of each individual situation. Facilities must be provided for the following operations: (1) receiving the refuse; (2) preparing the refuse for composting, including segregation of salvable and of non-compostable material, and shredding of the remainder to desired particle size; (3) stabilizing the shredded material by composting; and (4) preparing the compost for marketing by milling, bagging, etc.

Mechanization is necessary for economically receiving refuse and preparing it for composting, and for preparing the final product for marketing. The unit process of composting, however, can be done in piles or windrows in the open or under a shed roof, or in enclosed structures. Economic considerations favor the pile or windrow because it can be turned for aeration by relatively simple machinery. It is, therefore, the method most used in present successful composting operations. There is nevertheless a considerable interest in developing an enclosed mechanical composter and a number of such devices have been proposed. In general, these proposals have involved the use of large volumes of forced air, with or without mechanical stirring, and various procedures for environmental control. The aim is the production of compost in a matter of hours instead of the two weeks or longer required in the open.

The amount of air proposed for several of the mechanical composters which have come to the attention of the authors indicates a lack of understanding on the part of the designer of the difficulty of forcing air through a composting mass, the loss of moisture if successful, and the oxygen requirements

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of aerobic composting. As noted in the original paper, the oxygen required to prevent anaerobic decomposition from developing is not great. Once the minimum aeration requirements are met the rate of decomposition is more a function of the nature of the materials being composted and of environmental conditions of moisture and temperature than of the amount of excess aeration.

High speed composting poses both technical and economic problems. In the investigations reported by the writers, leafy green vegetables were composted in less than five days, and made to have the physical appearance of compost in little more than 48 hours. With the higher carbon-nitrogen ratio of mixed municipal refuse, however, it seems unlikely that even with continuous recycling and the best environmental controls, a good finished compost can be produced quickly enough to make the composting machine economically competitive with a well-engineered open turning procedure. Except for the desire to make the mechanical composter economical, very rapid composting—two days instead of two weeks—is not particularly important anyway, because the demand for commercial quantities of compost is seasonal. However, since stock piling of compost is necessary there is no reason why some composting should not continue in the stock pile provided the material is sufficiently decomposed at the time of piling to be capable of reaching stabilization without further aeration and without becoming anaerobic. Thus a mechanical composter need not produce a highly stabilized product unless it is to be bagged at once, but it is doubtful that normal composting time can be reduced by more than 20 percent by taking advantage of stockpile composting.

Compost is at best a low value material, hence to have commercial possibilities the process must make use of efficient materials handling procedures requiring a minimum of machinery and power. For this reason the writers feel that composting without the aid of mechanical composters or digesters, but with efficient mechanization of the various operations involved will be the answer to successful commercial composting in much of the United States. Good progress has been made in recent months toward solving the equipment problems mentioned in the original paper, as well as toward improving the economic aspects through more effective operational procedures and reduction in land area requirements. Present designs for example, aim at minimizing initial grinding, and at facilitating segregation through suitable screening of incoming refuse. With this arrangement major grinding becomes essentially a final rather than an initial process.

On the basis of equipment designs and flow diagrams completed by competent consulting engineers during the past year it now seems probable that the cost of composting will be less than estimated in the original paper. In some places where salvage can be made to pay a share of the cost, composting can be done as cheaply as incineration. Selling prices of five or six dollars a ton—about the price of stable and steer manure—are now being anticipated by some private concerns seriously considering going into the business of commercial composting using already completed designs.

Because of the need for perfecting specialized machinery and determining its most economical use in practice, as well as the problems involved in advertising and selling the product, it seems likely that composting will be first put on a commercial basis by private enterprise rather than by municipalities. While composting is not expected to be the answer to the refuse disposal problems of all U.S. cities, nor to compete with sanitary landfill in favorable site locations, the writers believe that it has important possibilities where disposal by incineration may be indicated, where there is need for humus fertilizer, and that it is much nearer an inevitable reality than it was a few years ago.

Discussion of
"SEWAGE AERATION PRACTICE IN NEW YORK CITY"

by Richard H. Gould
(Proc. Sep. 307)

RICHARD H. GOULD,[1] M. ASCE—In their discussion Messrs. Milton Spiegel and Miles Lamb do well to emphasize the point brought out in the original paper that as aeration tanks are made smaller, treating the same sewage with the same oxygen demand, that facilities for supplying air must be made more ample per linear foot of tank. Indeed, as previously stated, the practical limits of furnishing a specific volume of air per foot of tank may well be the limiting condition in shortening aeration periods.

We speak of air supply in terms of cubic feet per gallon of sewage, or cubic feet of air per linear foot of tank. The real criteria, of course, is the amount of oxygen in the air supply that can be absorbed by the sewage and be made available to supply the oxygen demand of the biological life and maintain aerobic conditions. The efficiency of oxygen utilization thus determines the specific volumes of air that must be supplied. Oxygen demand tests, such as described by the discussors, are useful in suggesting ways of improving the efficiency of air utilization and in measuring the degree of efficiency.

Inasmuch as the rate of solution of oxygen in a liquid is proportional to the saturation deficit of the liquid, it is indicated that the greatest utilization of oxygen is obtained when low levels of dissolved oxygen are maintained throughout a large part of the aeration tank. Experience also dictates the desireability of raising this value at the effluent end to about 2.5 p.p.m. The provision of step inlet gates in the aeration tanks gives the operator the means of controlling the levels of oxygen demands and dissolved oxygen throughout the tank so as to best utilize the air being supplied and best control the biology of the process.

With the advent of abbreviated aeration methods there is need for improved methods of supplying oxygen at high unit rates. Much thought has already been given to this problem. A great deal of research and practical development has taken place in the field of diffusion media, its arrangement in different forms, the importance of bubble size, and other methods of injecting air into liquids. Further improvements are to be expected. It is known that the solution of oxygen is proportional to its concentration. Perhaps someday it will be found practicable to raise the oxygen level of the air stream—particularly for periods of high oxygen demand.

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Discussion of
"RESERVOIR MALARIA CONTROL
AND SANITATION PROBLEMS"

by Frank B. Wood
(Proc. Sep. 399)

FRANK B. WOOD,[1] A.M. ASCE.—The writer agrees with Mr. S. Leary Jones that "Because of the varying uses of water and the different abilities of streams to receive sewage or waste, each section of a stream becomes a separate problem." Construction of a dam, creation of a storage reservoir and operation of the project; particularly the schedule for and rate of water releases, increase in the flow through time of the stream section changed by the impoundment, temperature and quality of the water released, agitation of the water at and below the dam; modifies the abilities of the downstream sections of the stream to receive sewage or wastes.

Flushing of a polluted section of a stream is beneficial but as brought out by Mr. Jones, sound planning and management of reservoirs are necessary in connection with minimizing the effects of pollution below the dams. Minimum discharge should generally be sufficient to prevent an increase in the pollution problem and when practicable should be sufficient to eliminate it. The many and varied interests of the stream should be considered and the planning and financing of a project should include estimates of the various losses and benefits and equitable assessments for such benefits and reimbursement or adjustment for the losses.

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Discussion of
"TWIN OPPORTUNITIES:
CONSERVATION AND ENGINEERING"

by Clarence Cottam
(Proc. Sep. 419)

CLARENCE S. JARVIS,[1] M. ASCE—During some fifty years of professional engineering practice, mainly concerned with conservation, control, and beneficial use of our water resources, the writer has observed the transition from eager groping to confident scientific approach in matters requiring coordinated efforts if maximum benefits are to be realized. An important milepost in the writer's memory was the assignment of the author of the paper under discussion, to represent the Fish and Wildlife Service in the comprehensive planning for mammoth Federal conservation projects located in both midwestern and far western States, more than twenty years ago. The author's continued responsibility throughout the intervening period evidently attests his satisfactory service, culminating in his masterly address as recorded in the paper under discussion.

The project for transforming dozens of glacial lakes, ponds, and meadows, to regulating reservoirs for late spring and early summer runoff, to be released in mid-summer or later for irrigation of desert lands, by the Provo Reservoir Company, with storage sites at elevations ranging from 9,000 to 10,200 feet above sea-level, (described in Eng. News of Aug. 26, 1915, beginning on page 394) demonstrated the need for mosquito control if man and his draft animals were to survive. During preliminary stadia surveys, it required full-time duty for an assistant to wield a towel or other fabric to disperse the swarms of mosquitoes from the writer's face and shoulders and to permit unhampered use of the transit telescope. The draft-horses and mules, no matter how closely hobbled, would leave the lush meadows and make as many miles on the down-grade as possible before morning, endeavoring to escape the mosquito plague. The water-lizards that infested the lakes and ponds, to the exclusion of fish, apparently observed a truce with mosquitoes and larvae.

Planting of fingerling trout in the lakes and ponds, dictated either by blind groping or horse sense, brought prompt relief, so that the mosquito menace thereafter was quite comparable with that to be met with in the irrigated fields of lower valleys. Peak flood runoff was reduced, and release of storage maintained the irrigation supply throughout the late summer.

Somewhat similar experiences attended many of the new reclamation projects of Western States, and opened up vast areas to intensive production and home-making. The co-ordinated programs for engineering and conservation projects have paid generous dividends, not the least of which are the marvelous hunting and fishing privileges where game is plentiful and thriving under wise protective regulations.

Now that interest has been revived in the proposed freshening of various arms of San Francisco Bay, as outlined by the writer in Paper No. 1472,

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Trans. Am. Soc. C.E., vol. 84, 1921, and by others at either earlier or later dates, it would be well to inquire whether the needful co-ordination of detailed plans and procedures has begun in earnest, to insure that the twin opportunities in conservation and engineering may result in the utmost benefits and values to the localities, the State, and to the nation. Such remarkable growth in population and industrial as well as agricultural development has taken place in recent decades throughout California, and particularly along the Coastal belt as well as the central valleys, with resultant overdraft on ground water reserves, it seems imperative to initiate some major projects to increase available water supply, or to utilize the millions of acre-feet that waste yearly.

The author's presentation is the most informative and valuable contribution in the outlined field of twin opportunities that the writer has yet seen, and he confidently awaits developments in broad fields along the lines as recommended therein.

Discussion of
"INCINERATION AND ALTERNATIVE
REFUSE DISPOSAL PROCESSES"

by Ralph Stone and F.R. Bowerman
(Proc. Sep. 471)

GEORGE R. THOMPSON,[1] M. ASCE—The paper is very comprehensive and the subject matter well organized. It is a difficult subject to treat satisfactorily because of the many variable interdependent factors involved. It would be more in order to suggest further study and elaboration of the subject than to offer critical comments on the paper.

More statistical information from other sources would be helpful in evaluation of generalized findings for specific cases.

Incineration is evaluated on basic factors—historically, economically and technically. A fourth important factor is that of public acceptance of the entire system of collection and disposal.

Influences of collection and other factors on quantity, state that back yard, alley or side-of-the-house pick-up tend to produce greater quantities than does curb placement for collection. No reason is given for this apparently inconsistent statement. The question arises as to what becomes of the refuse that is not collected. A further statement that compacted refuse makes it more difficult to burn is open to question, as the compaction is usually of small degree and totally lost in handling the material at an incineration plant.

The introduction of the transfer station is primarily dependent upon length and cost of haul by the collection units direct to the disposal point versus the cost of additional handling into a transfer unit. If the collection units are relatively small and the haul is long, a transfer station may be indicated. On the other hand, larger collection units direct to the disposal point may prove more economical than the transfer station.

Salvage can undoubtedly best be performed by private contractors who are better aware of the fluctuating market value of salvage materials and who have established sales outlets. Generally speaking, such an operation by private enterprise with a profit motive is more successful than when a governmental unit attempts to carry on a commercial enterprise.

Hog feeding of municipal garbage is definitely on its way out, primarily because of disease. It can be used successfully only when cooking control is under direct supervision of a governmental agency.

Composting is still in the experimental stage. Michigan State College at East Lansing has a pilot plant and is giving the subject intensive study. Its financial success depends upon being able to market the product produced in an area where raw material is available. Since marketing of the product is involved, composting might well be left to private enterprise.

Reduction methods generally are not profitable. Plant odor nuisance, long hauls and non-profitable disposal of the end products have about eliminated this method of disposal.

1. City Engr., Detroit, Mich.

Land disposal sites within economic haul, in the vicinity of large cities, are virtually non-existent. Open burning is a nuisance and the inclusion of garbage is unsanitary because of odor, rats and flies.

Sanitary land fill disposal is satisfactory if an acceptable site within reasonable length of haul is available and the operation is well conducted. Land fills are not suited to carrying superimposed loads of structures, roadways or air port runways. Even when used for parks, special attention has to be given for growing of trees.

The sanitary fill may be used as an ash dump from incinerators, which indicates that incineration is a good method of conserving land available for dumps. It is unusual to consider incineration as part of land fill, as a dump for incinerated ash is quite a different problem from a dump for garbage and combustible refuse.

Fills in swamp areas, using water or land transportation or a combination of both, can serve the dual purpose of making valuable land and disposing of refuse. Care must be taken to select sites and methods where nuisance will not result.

Garbage grinding at the point of food preparation is a rapidly growing, economical, sanitary and convenient method of disposal. It is increasingly becoming the modern method of disposal. Savings to municipalities will not be appreciably reflected until garbage collection by truck within a given area can be supplanted by grinding. Commercial grinding often effects a great saving for food producing companies when collection would otherwise have to be paid for as a service charge. Municipal grinding stations for raw garbage or wrapped garbage is still in the experimental stage, but may be competitive with incinerators. However, it does not answer the disposal of other refuse.

Incineration is well treated at length, both from historical development and practice, and from other considerations, including design and thermodynamic calculations. The location of incinerators and the problem of traffic to and from the plant from a public standpoint are of the utmost importance. Incineration is probably the most common method of disposal of garbage and combustible refuse in large cities of the United States. Even though the plants are well designed, well operated, properly screened, and located where traffic concentration does not pass through residential neighborhoods, there is much local opposition to such plants in or near a residential area. While they should be located at the center of load for the most economical haul, this is of secondary consideration to their public acceptance.

The ideal incinerator is one that would take any rubbish, combustible and incombustible, together with garbage wrapped or raw, and burn it economically, without nuisance. Such an incinerator eliminates the dual collection of garbage in one truck and other refuse in a second truck.

The paper is so well written that the foregoing constitutes comments rather than criticisms. The article is well illustrated with charts, photographs and diagrams and the authors are to be complimented on their work.

WILLIAM A. XANTEN.[2]—The field of refuse disposal is one upon which it is most difficult to generalize without subjecting the result to misinterpretation. Local conditions involving the area and population of a community, its character, its climate, and many other factors regarding it, must be given careful consideration and study before a practical and economical solution is reached. Particularly does this apply to the large and densely populated

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cities, where the problem is vastly complicated by the absence of short haul low ground for the final disposition of huge quantities of solid wastes, and where the methods utilized must of necessity be of a high sanitary standard in order to satisfy the requirements for nuisance-free performance. Nevertheless, Messrs. Bowerman and Stone have outlined the subject in masterful style, and it is impossible to quarrel with most of their conclusions. This discussion will, therefore, be confined primarily to the phases of the report dealing with incineration and fly-ash control.

It is noted that the report discusses the relatively high cost of incineration from the standpoint of both Capital Outlay and operating costs. The picture in this respect is not as bleak as it seems. A most significant factor is the marked trend in the United States toward the production of greater and greater quantities of combustible rubbish and lesser and lesser quantities of garbage and ashes. In the City of Washington from 1930 to 1950 the per capita production of these three classes of refuse have fluctuated as follows:

	Ashes	Garbage	Trash
1930	154,056 C.Y.	189,278 C.Y.	295,790 C.Y.
	0.32 C.Y./cap.	0.39 C.Y./cap.	0.61 C.Y./cap.
	417 #/cap.	390 #/cap.	135 #/cap.
1940	146,077 C.Y.	201,850 C.Y.	1,329,249 C.Y.
	0.22 C.Y./cap.	0.30 C.Y./cap.	2.00 C.Y./cap.
	286 #/cap.	300 #/cap.	444 #/cap.
1950	127,406 C.Y.	183,670 C.Y.	3,174,151 C.Y.
	0.16 C.Y./cap.	0.23 C.Y./cap.	3.95 C.Y./cap.
	208 #/cap.	230 #/cap.	880 #/cap.

With the unit weight of refuse being constantly reduced by the introduction of lighter and more combustible material it is obvious that incinerator plants are handling much larger volumes of material. It would appear that with the continuing use of frozen foods and the ever increasing installation of garbage grinders this trend should continue. The point to be made is that substantial increases in plant efficiencies have been required to hold costs of operation at present levels, and these costs on a tonnage basis can hardly reflect the volumetric increase in work performance due to such marked changes in the quality of material handled.

Such changes also require incinerator design considerations substantially different from those applicable to the situation in previous years. While Capital Outlay costs on a per-ton basis show a trend upward, it must be borne in mind that such unit costs are not necessarily comparable when radical improvements in design, or more conservative ratings are applied in general to the essential plant facilities. New York City reports that the use of preheaters for boosting temperatures of the supplementary air systems, have been discontinued in recent designs, current experience having indicated that their infrequent use on excessively wet refuse does not warrant the overall installation cost of about $250,000. In Washington, D.C. and Baltimore, Maryland, plants now under construction have been designed to accomodate and are equipped with an "extra" crane (three instead of two), so as to avoid the loss of production involved in potential crane breakdowns, and to permit as well adequate crane maintenance procedures. Installation of mechanical stoking units, sectionally supported walls, increases in pit capacities, provision of adequate combustion and suspension chambers, and other accompanying

design improvements, have all tended to place emphasis on increasing plant efficiencies. Together with the increase in the construction cost indices in the past decade, this represents a formidable surge toward higher unit costs for erecting incinerators. The surprising fact is that under such circumstances such costs have advanced so gradually and so nominally.

The question of method of disposal is sometimes one which of necessity must be solved by resorting to incineration. The Cities of New York, Washington, Philadelphia, Baltimore, and many others of comparable size are rapidly finding it more and more difficult to locate and conserve areas suitable for land filling purposes even for non-combustible refuse and incinerator residue within reasonable hauling distances. Since 1941 the controlled open-burning of combustible rubbish in excess of available incinerator capacity in the District of Columbia has been a method utilized as an alternative to sanitary-landfill for which areas were not available. During this period some 30,000,000 cubic yards of rubbish have been incorporated in a 600,000 cubic yard landfill. This could only be accomplished by an operation which involved (a) the maintenance of rigid separation requirements for rubbish, (b) the removal by magnets of all ferrous metals after burning and (c) a well-controlled burning and quenching operation. Despite the extreme care exercised such a method involves the creation of a smoke-nuisance which could only be tolerated pending the construction of additional incinerator capacity. The cost of this method of handling rubbish for disposal is approximately 20 percent of the cost of handling such material through a modern high-temperature incinerator. Nevertheless, the area utilized for this purpose is rapidly being filled, and no alternative location can even be considered, so that the more costly but more satisfactory and relatively nuisance-free method of plant incineration has become an absolute requirement in the District of Columbia.

It should not be concluded from the above that the sanitary landfill method of disposal will not continue to be utilized as a most satisfactory and economical method for smaller communities or for that matter, larger communities where suitable and adequate acreages are readily available for long-range usage. Nevertheless, the trend toward incineration in large cities will undoubtedly continue and the collateral problems of strategic plant location, waste heat utilization, and fly-ash control become increasingly important.

Inasmuch as the cost of refuse collection is seriously affected by length of haul, the strategic location of incinerators is of paramount importance. Attempts to program general salvaging operations in connection with the operation of such plants is not conducive to nuisance-free performance. In order to further the acceptance of such installations in commercially zoned areas, and for that matter in some instances adjacent to high-class residential areas, the primary consideration for the future would seem to be pleasing architectural treatment and careful plant maintenance. Plant capacities while geared to the overall problem should be limited to reasonable size.

The utilization of waste heat is a subject which should be weighed carefully from an economic viewpoint. Here again local conditions with respect to existing power rates and potential outlets for raw steam will play the deciding role.

The subject of fly-ash control is of universal interest and on this count Messrs. Stone and Bowerman have indulged in generalizations which are not of much help to the designing engineer. It should be emphasized that the removal of particulate matter from incinerator stack gases is a problem considerably different than that of dealing with the same problem in boiler plants. Electrostatic or cyclonic precipitators have not demonstrated their

effectiveness in dealing with the situation. The particles carried in the gases from the burning of cellulose material lack density and are not spherical in shape; being difficult to ionize and having a tendency to scale when subjected to cyclonic precipitation. Temperature conditions are another difficult factor to overcome. Common to all mechanical treatment processes is induced draft, thereby introducing another element of maintenance cost and noise of operation to be avoided if at all possible.

Experience with stack discharges at the municipal rubbish incinerators of the District of Columbia would indicate that great improvements can be made in the design of combustion and suspension chambers and that perhaps more emphasis should be given to this approach in an effort to come up with the proper combinations to permit the operation of plants under natural draft. It is believed that satisfactory results can be achieved to the point of reducing stack discharges to approximately 0.4 pounds per 1,000 pounds of flue gases or even lower, and that by providing incinerators with the combustion and expansion chamber design and capacity required to accomplish this will provide adequate space to introduce experimental systems of handling the gases for further reduction, if required. The subject is covered in more detail in a paper by the writer discussing Mr. Richard C. Corey's Paper on "Some Fundamental Considerations in the Design and Use of Incinerators"—1951—Air Pollution—McGraw-Hill.

This point of view is sustained by the City of New York as indicated in the following language from a report by Casimer Rogus, Director of Engineering, Department of Sanitation, to the A.P.W.A. Convention at New Orleans, in October 1953:

"Substantially sized expansion chambers (lined with firebrick) reduce air velocities from 15 f.p.s. in the preceding combustion chamber down to 5 f.p.s., all in the interest of completing the combustion but more particularly to settle out flyash. Because flyash, soot, fume, and odor emissions from incinerators have stirred public demands for improved air pollution control the City has expended considerable effort in investigating the merits of several types of dust removal systems. The high temperatures and large volumes of gases produced in incineration have negated economic installations of the conventional type dust removal systems such as cyclonic separators, mechanical filters, electric precipitators, water spray washers, or suitable combinations of these. Laboratory tests and research on pilot models of the prototype expansion chambers, by the Battelle Memorial Institute, hired for this purpose, developed the conclusion that expansion chambers of the present design, modified only through the installation of some relatively simple horizontal baffles and skimmer plates would reduce the flyash emissions to about .56 lbs. per 1,000 lbs. of gas (corrected to 50 percent excess air). This value is well within the permissible limit of .85 lbs. specified by the New York Department of Air Pollution Control."

Very little precise information is at hand regarding stack emissions from large municipal incinerators. Ringelmann Chart measurements do not provide a satisfactory barometer of performance. Continuing research and actual field studies for the two-fold purpose of providing data for the establishment of proper criteria for regulatory agencies to apply to the local situation, and to provide, if at all possible, a simple method (similar to the Ringelmann Chart method for oil and coal burning plants) for measuring performance for stack discharges from refuse incinerators.

Approaching the fly-ash problem of incinerators by the installation of mechanical systems (either wet or dry-type) appears at the present time to be

largely experimental and very costly both in first cost and/or maintenance. Based on experience in the District of Columbia and New York City, particularly, as well as other large municipalities where modern refuse incinerators are either recently completed or under construction, it is probable that even more satisfactory results can and will be achieved by the provision of more carefully designed combustion chambers and flues, tall chimneys, operation under natural draft, the use of specially designed baffles; and the application of operating procedures more conducive to nuisance-free performance than has been customary in the past.

Finally, it should be stated that the management and engineering problems involved in the economical and proper handling of refuse collection and disposal in large and densely populated communities are difficult and complex. It cannot be too strongly emphasized that they should be solved by engineering studies predicated on the local conditions. Apparently there has been greater recognition of this fact in recent years, and the publication by the A.S.C.E. of the informative paper by Messrs. Stone and Bowerman serves to accentuate the importance of this conclusion.

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